NAVIGATING THE FUTURE OF ROADS – RESPONDING TO THE IMPERATIVE OF SUSTAINABLE DEVELOPMENT

ABSTRACT

Roads are a vital component of our social and financial systems, providing mobility corridors for people, enabling freight networks to transport food, goods and services, and distributions paths for emergency services and disaster relief teams. In the coming decades a number of new factors will face road agencies related to climate change, resources, and energy. These factors include predicted resource and materials shortages, increases in energy and natural resources prices, increased costs related to greenhouse gas emissions, changing use and expectations of roads, along with shifting weather patterns and changes to frequency and intensity of weather events. The response to such factors will need to be dynamic and flexible, and will need to draw on the strengths of existing processes while considering a range of new trends related to the environment, society, and the economy.

This paper will highlight the findings of a national research project supported by MRWA investigating ways to reduce the environmental pressure of roads. The paper and presentation will be based on the findings of a Sustainable Built Environment National Research Centre project, with the first round being completed in September 2012, and supported by Main Roads Western Australia, QLD Department of Transport and Main Roads, Parsons Brinckerhoff, John Holland Group, and the Australian Green Infrastructure Council (AGIC). The paper and presentation includes the findings of stakeholder engagement workshops held in Perth and Brisbane.

INTRODUCTION

In the coming decades the design, construction and maintenance of roads will face a range of new issues and as such will require a number of new approaches. In particular, road authorities will be required to consider and respond to a range of issues related to climate change, and associated extreme weather events, such as the extensive flooding in January 2011 in Queensland, Australia (See Figure 1). Coupled with diminishing access to road construction supplies (such as aggregate), water scarcity, and the potential for increases in oil and electricity prices, this range of challenges bear little resemblance to those previously faced. In Australia, state and federal authorities face further pressures given the variety of needs resulting from the country's geographical and population diversity, expansive road networks, road freight requirements and relatively small population base.

Figure 1. Effect of extreme weather events, Queensland January 2011 *(Weerakoon)*[i]

With emerging issues related to environmental impacts and carbon legislation, economic risks and social demands, long-term planning and resilience-building is urgently required to provide reliable and extensive road networks in future. This is particularly so in Australia, where 814,000 kilometres[ii] of road network spans a wide range of geographic areas (See Figure 2). The cost of road construction in Australia is estimated to be in the order of $17.5 billion per year. The road maintenance cost is estimated to be in the order of $5 billion per year and rising.[iii]

This paper summarises research undertaken as part of the ‘Future of Roads’ project of the Sustainable Built Environment National Research Centre (SBEnrc)[iv] in Australia that is exploring the variety and complexity of future pressures on roads. The project is supported by the state departments of Main Roads Western Australia, Queensland Department of Transport and Main Roads, in addition to industry partners Parsons Brinckerhoff, John Holland Group, and is supported in-kind by the Australian Green Infrastructure Council (AGIC). The research is focusing on two Australian states (Queensland and Western Australia) as examples to discuss geographical considerations and to draw together emerging common implications for cost-effectively managing road construction and maintenance related carbon emissions.

Figure 2. Image of Australian major road networks

CHALLENGES AHEAD FOR ROAD CONSTRUCTION AND MAINTENANCE

Due to rapidly expanding economies around the world, significant changes in weather patterns, and predicted increases in energy and resource prices,[v] much effort around the world is being put into responding to such challenges with creativity and innovation.[vi,vii,viii] The clear message emerging is that an opportunity exists to transform the way road infrastructure is conceived, planned and constructed, to assist society to respond to climate change, reduce a range of environmental pressures, and improve the mobility of citizens.

It is important to consider the direct environmental impact of roads because of their role in our society and the scale of the infrastructure we have built to date. It is also important, but more challenging, to consider the indirect environmental impact of roads through their end-use as transportation corridors, and how this might be addressed through strategic directions for transport infrastructure. For example, roads support an automobile industry that employs millions of people and sells a copy of its product every 1.5 seconds.[ix] Road infrastructure also supports vehicles that combust 310,000 barrels of oil every day in Australia and emit 17 percent of Australia's greenhouse gases, in turn threatening global climatic stability, local ecology and agricultural industries.[x]

The use of roads has become a core part of an economies activity, for instance making a cup of coffee can be based on nearly 30 different transport related activities. However, while the economic benefits of road construction and use are well known, the environmental impact and associated future economic impacts are typically underestimated. For example, each kilometre of road constructed, and associated infrastructure, requires large quantities of aggregates, concrete, asphalt and steel to be sourced, transported and placed. A typical two-lane bitumen road with an aggregate base can require up to 25,000 tonnes of material per kilometre, showing why aggregates are the most mined resource in the world. The emissions from the mining, transportation, earthworks, and paving associated with road construction, as well as emissions from road users, makes it one of the greatest contributors to climate change, some 22 percent of global carbon dioxide emissions.[xi]

With this in mind, the coming decade will see a change in focus on 'environmental management', from minimising carbon footprint and ecological disturbance, to the second generation of environmental reporting that will require a focus on issues like the availability (resource scarcity) and transport of resources required (reducing greenhouse gas emissions) to construct and maintain roads. It is clear that across government and industry, momentum is increasing to achieve meaningful reductions in the environmental impacts during road construction. There are a number of opportunities throughout the various stages of road construction and maintenance that could minimise environmental pressures, as outlined in Table 1.

Table 1: Strategic areas for reducing environmental pressures related to road construction and maintenance

Asphalt	Concrete
Alternative Aggregate Materials – *Redirect waste products to replace extracted aggregates, such as:* –Reclaimed Asphalt Pavement –Glass –Crumb Rubber Modifier –Recycled Construction and Demolition materials Bitumen Alternative –Polymer modified bitumen –ecoPave bio-binding agents –Vegecol by Colas –Pine resin and tall oil Low Energy Asphalt Production Process	Alternative Aggregate Materials – *Redirect waste products to replace extracted aggregates.* *Cement Alternatives–low carbon concrete* – *Geopolymer alkali activation (AUS)* – *Magnesium oxide - Novacem (UK)* – *Flash Calcining – Calex (AUS)* – *Phosphogypsum (POR)* – *Bio-based cements and self-healing concrete (Netherlands)* Processes – *The potential to achieve carbon*

– *Warm mix technologies.* – *Cold mix applications*	*storage in concrete, in particular magnesium-phosphate cements*
Aggregates Processes	**Aggregate Materials Selection**
Transportation – *Increased fuel efficiency in transportation and distribution vehicles* Placement – *The potential to use saline and non-potable water in road base* – *The use of non-potable water or non-toxic chemicals for dust control*	Alternative Materials – Redirect waste products to replace extracted aggregates, such as: –Recycled Construction and Demolition materials –Glass –Ash –fly, bottom, incinerator –Recycled Vehicle Tyres –Bauxite residue In-situ Stabilisation – Used to replace need for crushed rock aggregate, such as: –Foamed bitumen –Cement blends –Geopolymers –Quick lime and lime/slag/flyash triple blend –latex bio-binders

Source: Whistler, L., Hargroves, K., Newman, P. Desha, C., and Farr, A., and Surawski, L. (2010)[xii] (*This table has been informed by literature review and stakeholder workshops as part of the SBEnrc 'Future of Roads' project.)*

Road building is inherently an efficient practice that seeks to minimise costs related to construction and maintenance, with a range of practices that can be called upon to address current and future environmental issues. Such practices include:

- balancing earthworks to optimise cut and fill,
- utilising local sources to minimise the import of materials,
- stablilising additives to adapt local marginal materials,
- ensuring impacts on the local environment and biodiversity are appropriately managed and revegetated,
- road water runoff capture and treatment,
- optimising pavement thickness for anticipated conditions and loads, and
- effective scheduling of associated capital expenditure and rapid delivery.

These practices have enhanced Australia's extensive road infrastructure over the last two decades and will be a key part of road building in the coming decades as part of the response to a changing climate. In order to compliment such practices a range of new practices will be developed in response to a range of new design and performance considerations, in areas including material extraction, transporting, earthwork, and paving. The next generation of road infrastructure analysis is focused on reducing environmental impacts of road construction, including such initiatives as investment in recycled materials.

CONCLUSION

The roads in Australia form part of a global network greater than 34 million kilometres,[xiii] nearly 90 times the distance from the Earth to the Moon. Considering the magnitude of our public infrastructure, the future environmental impacts, economic risks, and social trends associated with roads will have a significant impact on long term costs and service for citizens. Australian road authorities are investigating the pressures facing the future of roads and considering how a strategic response can be informed.

To date innovations in sustainable road construction practices have been given little incentive, with technology focused on engineering design for speed and safety of roads. Internationally, road networks are entering a new chapter in formation and function – the next 'wave of innovation' – including for example natural rubber being used to bind marginal (local) material, plant based bitumen alternatives, pavements that generate energy and roads that incorporate recycled plastic bags.

Alongside such innovation, the coming decade will see a change in focus from 'environmental management' that minimises footprint and ecological disturbance, to a second generation of environmental reporting requiring a focus on issues regarding availability (alternative sources) and transport of resources required (reducing greenhouse gas emissions) to construct and maintain roads. Such a shift in focus is imperative and urgent to give road authorities time to create road networks that are resilient to significant environmental and resource related challenges in future.

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